**IoT-Enabled Smart Irrigation System Using ESP32**

Hitarth **22BRS1328**

Aditya Kumar **22BRS1190**

Ayush Raj **22BRS1117**

**Introduction**

**Agriculture**, involving the cultivation of crops, plays an important role in

sustaining and nourishing the human population. Beyond providing food, it

contributes to poverty reduction and drives economic growth. Globally,

agriculture accounts for approximately 4% of the gross domestic product (GDP)

and is projected to feed a population of around 9.7 billion by 2050 .

Throughout history, technology has been involved in agriculture.

Early farmers used rudimentary tools made from wood or animal bones over 12,000

years ago . As time progressed, more sophisticated tools emerged. In India,

tractors became commonplace on farmlands .

Now, as we know, Water is a critical factor in plant growth and

nutrient distribution. Irrigation is a method which involves applying water to

the soil through pumps, tubes, and sprays, which is particularly crucial in

regions with low rainfall . Among various irrigation methods, drip irrigation

stands out for its efficiency. In arid desert countries, where water

conservation is paramount, drip systems are a perfect fit. These systems

deliver water directly to the soil near plant roots in the form of droplets,

significantly reducing water wastage .

The Internet of Things (IoT) finds applications in data

collection, automation, and control across various domains. In the realm of

smart agriculture, IoT technologies have gained prominence . For instance, we

designed an intelligent IoT-enabled drip irrigation system using an *ESP32* microcontroller.

Our system incorporates components like a *relay module*, *soil*

*moisture sensor*, *temperature sensor*, *air*

*humidity sensor* and *water flow sensor*. We are integrating a custom mobile application

to collect irrigation data, enable automatic irrigation and visualized

temperature, soil moisture, and air humidity trends. The system responds

dynamically: when the soil is dry and conditions are favourable, the ESP32

opens the valve to irrigate the field. Users can also manually control the

system based on humidity readings.

**Literature Survey**

Previous research includes smart irrigation systems and smart

drip irrigation systems [10,11]. References [12,13] offer overviews of smart

irrigation systems, covering wireless communications, irrigation methods,

applicable sensors, and monitoring types. Reference [14] delves into irrigation

monitoring, control, and scheduling, while [15] explores IoT use cases,

challenges, and agricultural issues.

In [16], a smart irrigation system utilized a resistive soil

moisture sensor, temperature sensor, water flow meter, and Arduino UNO single

board computer (SBC). It monitored temperature and soil moisture, irrigating

the field if conditions were dry or the temperature exceeded 30°C. [17]

describes a smart system for monitoring and controlling agricultural production

via IoT, reducing farmer workload.

Another smart irrigation system in [18] used a resistive soil

moisture sensor, temperature sensor, air humidity sensor, and Arduino UNO SBC.

It displayed temperature and humidity readings, activating the motor when soil

was too dry. [19] proposed a solar-powered smart drip irrigation system with a

node MCU, monitoring temperature, humidity, and soil moisture to control pump

activation. [20] suggests a smart farm using LoRaWAN.

*Our enhancements to prior work include*: We utilized a combination of ESP32

microcontroller, Arduino UNO, water flow sensor, Infrared sensor, soil moisture

sensor, and temperature & humidity sensor, each depicted concisely in our

own mobile application. Prior works usually used ready made IoT platforms like

Blynk, Things Speak, ESP Rainmaker etc but we have developed our own app using

flutter framework giving full flexibility to customize the functionality of the

app rather than being constrained by the IoT platforms’ limitations. We also added

multilingual support of the app so that regional farmers all over India can use

the app without any language barriers. Existing works had used English predominantly

in their frontend dashboards disregarding the fact that local farmers especially

in India are not literate in English rendering them unable to utilize the benefits

of technology in their farming purposes. Also most existing works focused mainly

on the Irrigation aspect of IoT in farming but we are extending the scope by suggesting

other improvements such as adding support for smart fertilizer dispensing with

the guidance of NPK sensor, automatic pesticides/insecticide dispensing and alarm

system if detected by IR sensor which can be threat to the crops, pH value monitoring

and much more.

Gaps and issues in our work

Our project implemented a miniature concept prototype of a Farm Management System using cheap and practically unreliable components to demonstrate the full potential of IoT in revolutionizing farming practices in India. While in real world applications much more reliable and industry grade sensors and other components must be used which have much higher reliability, scalability and redundancy.

Some recommendations are-

|  |  |  |
| --- | --- | --- |
|  | Used | Suggested |
| Soil moisture | SeeedStudio Moisture Sensor | IP68 RS485 Soil Moisture and Temperature |
| Water flow | 1/2 inch Water Flow Sensor YF-S201 | DN32 Water Flow Sensor |
| Water pump | 3-9v DC mini water pump | KisanKraft Water Pump   1.1kW (1.5hp) |
| IR sensor |  |  |

We failed to interface relay module with ESP 32 as the 3.3 Volts digital output signal of ESP 32 could not toggle the active-low relay module which requires 5 Volts to detect change in input from LOW to HIGH. Although this could easily be achieved by amplifying the digital output of ESP 32 before feeding it to the relay module.

Even though we developed our own made in India app for Indian farmers to show the data, we utilized a third party database service i.e. Firebase instead of creating our own database and hosting data about the soil of India on Indian soil.

Despite the amazing wireless capabilities of ESP32 it is a challenge to make dozens of ESP32 communicate smoothly in the middle of a field where WiFi reach is minimal. We also hard-coded the ESP to connect to a singular WiFi network rather than using a more dynamic approach of WiFi provisioning or BLE provisioning.

We did not address the issue of how the sensitive electronic components should be safely mounted in a harsh environment like a farm protecting them from unideal conditions such as changing temperatures, sunlight, rain, storm, water, hail, insects, pests ,etc

**Methodology**

The ESP32 serves as the system’s central unit. We connected it to various sensors and a relay. The temperature and soil moisture probes were inserted into the soil, monitoring their respective levels. Additionally, the water flow sensor tracked water flow rate, while the humidity sensor measured air humidity. The system employed a relay to open the solenoid valve for watering. Using Wi-Fi, the ESP32 communicated with the Blynk cloud via a mobile app or web dashboard. We utilized the Blynk app for irrigation data collection, manual valve control, and plotting soil temperature fluctuations.

*Materials Used:*

Microcontroller-ESP32 : The ESP32 is a low-cost, 32-bit microcontroller. It has built-in Bluetooth and Wi-Fi, making it useful for IoT applications. It can accommodate multiple sensors and devices with 48 general purpose input–output (GPIO) pins. We used the inbuilt Wi-Fi of the ESP32 to communicate with the Blynk mobile app or web dashboard. ESP32 sends irrigation information to Blynk cloud. We can control the valve or set the irrigation time using the mobile app.

Moisture Sensor:  We used a SEN0308 DFRobot soil humidity sensor, which detects soil humidity and sends analog signals to the ESP32. The SEN0308 is a capacitive moisture sensor that offers improved waterproof performance, increased length, and high corrosion resistance. It solves a critical issue encountered with commonly used resistive moisture sensor probes, which is probe corro- sion. The SEN0308 has excellent corrosion resistance and can be inserted into the soil for long periods.

We inserted the sensor probe into the soil. The sensor measures changes in capacitance that are caused by alterations in the dielectric due to humidity. It does not measure moisture directly but instead measures the moisture’s ions. The sensor sends analog signals to the ESP32 based on the measurement, which is converted to a digital signal by the ESP32.

Temperature Sensor: We used a DS18B20 one-wire bus temperature sensor probe. These sensors provide up to 12-bit temperature measurements in Celsius and have an alarm function with non-volatile user-programmable lower and upper trigger points. Each sensor has a unique 64-bit ID burned in at the factory to differentiate them, which allows us to control multiple sensors with a single GPIO pin of a microcontroller. This sensor’s significant advantages are its high accuracy and waterproofing

Air Humidity Sensor: We used a DHT22 humidity–temperature sensor. It is low-cost and uses a capacitive humidity sensor to measure the humidity in the air. It also uses a thermistor to measure the temperature. The data can be obtained from the data pin of the DHT22. The DHT22 is good for 0–99.9% humidity readings wit +/−2% accuracy.

Water Flow Sensor: The FS300A consists of a water rotor, a hall-effect sensor, and a plastic valve body. The water flows in through the inlet and out through the outlet due to the flow of water and the wheel rolls, and so does the magnet. The rotation of the magnet triggers the hall-effect sensor, which outputs high- and low-square waves. We calculate the water flow by counting the square waves.

Solenoid Valve: We used a hunter PGV one-inch solenoid valve, which is an electrically controlled valve.. A solenoid is an electric coil with a movable magnetic core. Applying an electric current to this coil creates a magnetic field, which moves the core and allows water to flow. If the current is cut off, the valve closes, and the water flow stops.

Relay: A relay is a simple electrically controlled switch. By sending a signal from the ESP32, we can turn the switch on and supply a 24 V AC to the solenoid valve and open it.

Step-Down Voltage regulator: The smart drip irrigation system is powered using a 12 V DC adapter. We used a step-down voltage regulator to supply the ESP32 with the 5 V needed for operation.

Results and Discussions

Conclusion

We were successful in building an IoT-enabled smart irrigation system. It provides an automation feature, where by analyzing the conditions with the inputs of sensors, ESP32 will open the solenoid valve and water the plants. We have also added a feature for safety check. If any intrusion occurs such as pests and insects, the app would update the status.

In our mobile app’s dashboard, we can also monitor soil moisture, temperature, and air humidity. It also shows the amount of water been used.

While the our system has been performing well, there are still some areas of improvement to explore, such as:

* Exploring the impact of watering the plants at the ideal temperature for maximum  
   water absorption.
* Clustering multiple valves to cover a larger area.
* Integration of solar energy system.
* Integration of more variety of sensors like pH sensors, wind speed sensors, rain sensors, and more.

References

1. World Bank’s comprehensive information on agricultural development, research, and data. Accessed on December 12, 2022. (https://www.worldbank.org/en/ topic/agriculture/overview#1)
2. Woods, M. and Woods, M.B. delve into the technology of ancient agriculture, from sickles to plows, in their 2011 publication by Twenty-First Century Books, Minneapolis, MO, USA. Pages 98-99. ISBN 978-0-7613-7269-1.
3. Bellis, M. provides a historical perspective on the evolution of farm machinery and technology from 1776 to 1990. Accessed on December 13, 2022. (https://www.thoughtco.com/american- farm-tech-development-4083328 )
4. The CDC provides an overview of the types of water use in agriculture. Accessed on December 13, 2022. https://www.cdc.gov/ healthywater/other/agricultural/types.html
5. Ranjan, S. and Sow, S. discuss the drip irrigation system for sustainable agriculture in their 2020 publication in Agric. Food.
6. Mangi, N. evaluates the performance of the drip irrigation system and its future benefits in his 2020 report in Sch. Rep.
7. Sathyapriya, E., Naveenkumar, M.R., and Dhivya, V. present an empirical study on drip irrigation at the National Conference on Micro Irrigation, TNAU, Coimbatore, India, held from March 1-3, 2017.
8. Verdouw, C., Wolfert, S., and Tekinerdogan, B. explore the role of the Internet of Things in agriculture in their 2016 review published by CABI International, Wallingford, UK.
9. Verma, D.K., Mishra, A., and Mishra, K. discuss the role of IoT in transforming agriculture into smart agriculture in their 2022 publication in Int. Res. J. Eng. Tech.
10. Ghosh, S., Sayyed, S., Wani, K., Mhatre, M., and Hingoliwala, H.A. propose a smart drip irrigation system using cloud, android, and data mining at the 2016 IEEE International Conference on Advances in Electronics, Communication and Computer Technology (ICAECCT), Rajarshi Shahu College of Engineering, Pune, India, held on December 2-3, 2016.
11. Swetha, R.N., Nikitha, J., and Pavitra, B. discuss the smart drip irrigation system for corporate farming using the Internet of Things in their 2017 publication in Int. J. Creat Res. Thoughts.
12. Obaideen, K., Yousef, B.A., AlMallahi, M.N., Tan, Y.C., Mahmoud, M., Jaber, H., and Ramadan, M. provide an overview of smart irrigation systems using IoT in their 2022 publication in Energy Nexus.
13. Gamal, Y., Soltan, A., Said, L.A., Madian, A.H., and Radwan, A.G. provided an overview of smart irrigation systems in their 2023 publication in IEEE Access.
14. Bwambale, E. and Abagale, F.K. discuss smart irrigation monitoring and control in their 2022 publication in the Encyclopedia of Smart Agriculture Technologies by Springer, Cham, Switzerland.
15. Mohy-eddine, M., Guezzaz, A., and Benkirane, S. discuss security issues and applications of IoT-enabled smart agriculture in their 2023 publication in Artificial Intelligence and Smart Environment. ICAISE 2022. Lecture Notes in Networks and Systems by Springer, Cham, Switzerland.
16. El Mezouari, A., El Fazziki, A., and Sadgal, M. discuss the smart irrigation system at the 10th IFAC Conference on Manufacturing Modelling, Management and Control MIM 2022, Nantes, France, held from June 22-24, 2022.
17. Mabrouki, J., Azoulay, K., Elfanssi, S., Bouhachlaf, L., Mousli, F., and Azrour, M. discuss the smart system for monitoring and controlling agricultural production by the IoT in their 2022 publication in IoT and Smart Devices for Sustainable Environment. EAI/Springer Innovations in Communication and Computing by Springer, Cham, Switzerland.
18. Gomathy, C.K., Vamsikumar, A., Karthik, B., and Purushothamreddy, A. discuss the smart irrigation system using IoT in their 2021 publication in Int. Res. J. Eng. Tech.
19. Yusuf, S.D., Comfort, S.L.D., Umar, I., and Loko, A.Z. discuss the simulation and construction of a solar-powered smart irrigation system using Internet of Things (IoT) and Blynk Mobile App in their 2022 publication in Asian J. Agric. Hort. Res.
20. Saban, M., Bekkour, M., Amdaouch, I., El Gueri, J., Ait Ahmed, B., Chaari, M.Z., Ruiz-Alzola, J., Rosado-Muñoz, A., and Aghzout, O.A. discuss a smart agricultural system based on PLC and a cloud computing web application using LoRa and LoRaWan in their 2023 publication in Sensors.